(D)

UNIVERSITY OF SOUTH CAROLINA

KINLEY CREEK WATERSHED
LEXINGTON COUNTY, SOUTH CAROLINA

AN ANALYSIS OF CONSTRUCTION ACTIVITIES IN THE PINEY GROVE AREA AND THE IMPACT ON THE KINLEY CREEK WATERSHED

A Research Project Submitted in
Fulfillment of Course
Requirements For
ECIV 797
Special Topics in Civil Engineering

By

John C. Alberghini
and
William C. Newton

Columbia, South Carolina

June 1995

ALBERGHINI. J.C

AD NUMBER	DATE 15 Dec 95	DTIC ACCESSION NOTICE

1. REPORT IDENTIFYING INFORMATION

A. ORIGINATING AGENCY
Naval Postgraduate School, Monterey, CA 93943

B. REPORT TITLE AND/OR NUMBER
An Analysis of Construction Activities in the Piney Grove area and the Impact on the Kinley Creek

C. MONITOR REPORT NUMBER
ALBERGHINI, John C. Thesis, U of S. Carolin June 95

D. PREPARED UNDER CONTRACT NUMBER
N00123-89-G-0529

2. DISTRIBUTION STATEMENT

APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION UNLIMITED

REQUESTER:

19960105 030

DTIC Form 50 DEC 91 PREVIOUS EDITIONS ARE OBSOLETE

File Copy

OM I

UNIVERSITY OF SOUTH CAROLINA

KINLEY CREEK WATERSHED
LEXINGTON COUNTY, SOUTH CAROLINA

AN ANALYSIS OF CONSTRUCTION ACTIVITIES IN THE PINEY GROVE AREA AND THE IMPACT ON THE KINLEY CREEK WATERSHED

A Research Project Submitted in
Fulfillment of Course
Requirements For
ECIV 797
Special Topics in Civil Engineering

By

John C. Alberghini
and
William C. Newton

Columbia, South Carolina

June 1995

ACKNOWLEDGEMENTS

We wish to acknowledge the support provided by the Lexington County Department of Planning and Development, especially the assistance of Mr. John Kludo in training us in the use of the GIS System and its applications in this project. In addition, we appreciate the background information provided by Mr. Flint Holbrook and Mr. Steve Bradley of the South Carolina, Department of Health and Environmental Control, Bureau of Water Pollution Control.

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION/BACKGROUND

In June 1992, a stormwater management study for the Kinley Creek Watershed was completed by Meadows et al. The goal of that study was to "develop a framework to resolve existing problems associated with stormwater runoff from developed areas and to anticipated and wisely plan for the effective management of stormwater and sediment in those areas to be developed." (Meadows et al, 1992) It included the development of a comprehensive model to simulate the hydrologic conditions of the watershed. By incorporating site specific data from Lexington County's GIS system into the Drain:Edge Program, the original authors were able to simulate the existing conditions on site and propose future changes to the watershed.

In recent years, residents in two residential subdivisions Southwest of the I-26 - Piney Grove Interchange have registered several complaints noting both an increase in the frequency of flooding (i.e. stormwater runoff) in and around their homes and a change in the composition of the runoff itself. Whereas the predominant deposited material in the past was composed of silt and sand, the residents now note a more clayey soil in the runoff. Because the clay runoff is causing a more noticeable problem (primarily property damage in the form of clay stained siding, basements, carpets etc...), much attention has been focused on the root cause of the problem and possible solutions or combinations of solutions to the flooding problems.

OBJECTIVES

The goal of this project was to evaluate the effect of recent road construction, in and around the Piney Grove - I-26 interchange, on the Kinley Creek Watershed (primarily the K-2 tributary). Specific objectives were to update the existing GIS data base and corresponding Drain:Edge link-node model to "current" conditions and evaluate various alternatives for changes in the watershed.

APPROACH

The general approach during this project was to first familiarize ourselves with the Kinley Creek Watershed. This was accomplished by (1) reviewing the original Stormwater Management Study conducted by Meadows et al. (1992), (2) review various topographic maps/aerial photos of the area for the years 1972 to 1989, (3) conduct interviews with city, county and state officials directly involved with the flooding issue, (4) conduct windshield tours of the watershed itself, and (5) inspect and photograph various portions of watershed during actual rainfall events. Appendix 4 is germane. After defining the extent of the problem, the next step involved modifying the GIS data base in an attempt to isolate various changes within the Kinley Creek Watershed, noting their incremental impact (or lack of impact) on the watershed. Appendices 1, 2 and 3 are germane. After modeling the watershed at various stages of development, we will simulate various modifications to the watershed (i.e. pond size, outlet device) and make recommendations accordingly.

DATA ACQUISITION AND DISCUSSION

After review and consultation with Lexington County Planning and Development, we used their GIS capabilities to analyze the Kinley Creek watershed response to the recent road construction and land use changes around the Piney Grove/I-26 interchange. Attempts were first made to construct the Kinley Creek watershed as it existed in 1970. We were trying to "create" a pre-existing condition that could be compared with 1995 conditions. This approach was soon abandoned when information on specific land use, watershed delineation and road size pertaining to 1970 became increasingly inaccurate. However, in appendix 1, we have included a "mock" 1970 case to take into account the increase of I-26 to three lanes from two lanes holding all other variables constant. We accomplished this by editing Lexington County's existing road file. Next, we found it more reasonable, due to the availability of historical data, to model pre-existing conditions for Kinley Creek that described the watershed in 1989. Specifically, we implemented existing road, land use, and watershed files which reflected the Kinley Creek watershed as it is today less the recent Piney Grove changes created by DOT construction. As the GIS data indicates, the change in I-26 to three lanes (1989) from two lanes (1970) had no effect on any watershed within the Kinley Creek Basin. Appendix 1 shows no change in curve number or PRF values when comparing the 1970 condition to the 1989 condition.

To get at the objective at hand, we simulated the digitizing

process GIS utilizes to add the Piney Grove and frontage road improvements. By changing the buffer file, we were able to accurately describe the width of each new road. In addition, we had to change the land use file to reflect changes induced by the borrow-pit (watersheds 133 and 132) and changes in the land between Piney Grove road and Grove Park Pond (watershed 700). After considering the existing conditions of these two areas, we decided to make two different 1995 models. One model would reflect open grass fields for land use in the borrow-pit and in the land adjacent to the pond. The other model would reflect an impervious surface for land use in these same regions. We chose to consider an impervious case for two reasons. First, after observing the condition of these areas during a five year rain event, we felt that the land was still acting like an impervious surface rather than as a grassy field as intended. Furthermore, an impervious analysis would give us some insight as to the effects on runoff during construction when the land in question was primarily compacted clay. Secondly, we learned that the two areas of land will most likely be commercially developed in the near future so that an impervious analysis certainly would be appropriate for permanent future conditions. The last two files in appendix 1 reflect the curve number and PRF changes forecasted by GIS for the conditions described above. As anticipated, the curve numbers and PRF values for the 1995 model which assigned the land use as impervious were considerably higher in the associated watersheds.

Given the four conditions described previously, we chose the Drain:Edge Stormwater modeling software to perform a runoff analysis of the entire watershed. By utilizing earlier work done by Meadows et al., 1992, we updated the link-node diagram for the Kinley Creek Basin to reflect Lexington County watershed delineation improvements. Figure 1 and Figure 1a illustrate the most current link-node diagram for the Kinley Creek Basin.

With the link-node network in place, we created the necessary batch files for the Drain:Edge analysis (see appendix 2) from the GIS data. Using Lexington County design storm information (see Figure 2) we analyzed all four models behavior to the 2, 5, 10, 25, 50 and 100 year design storm events. Tables 1 through 6 illustrate peak runoff rates at effected watersheds and nodes of interest (i.e. downstream nodes) for each storm event. In each case, the models were compared by calculating the percent increase in runoff experienced as the watershed became more developed. Tables 1 through 6 show a less than 8 percent increase in runoff at any one node of interest when comparing the 1989 conditions to the 1995 open field condition. As a matter of fact, if nodes 701 and 700 (the inlet and outlet conditions of Grove Park Pond) are ignored, the percent increase is less than 1 percent for all nodes of interest for every storm event. The greatest impact of the DOT construction appears to be in the immediate watersheds where land use changes have occurred. When comparing the 1989 condition to the 1995 impervious field condition the runoff increases are considerably more significant. Tables 1 through 6 illustrate

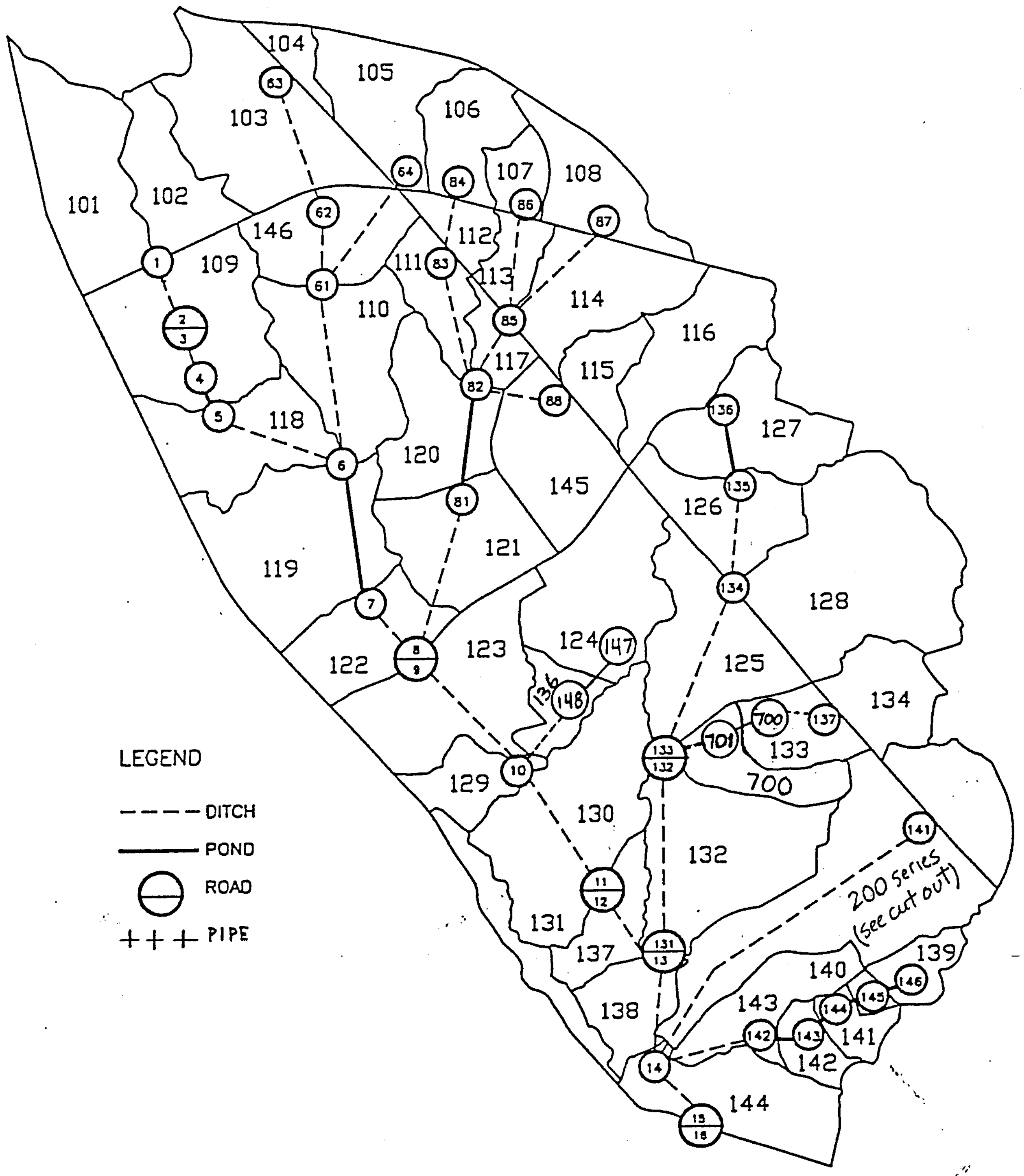
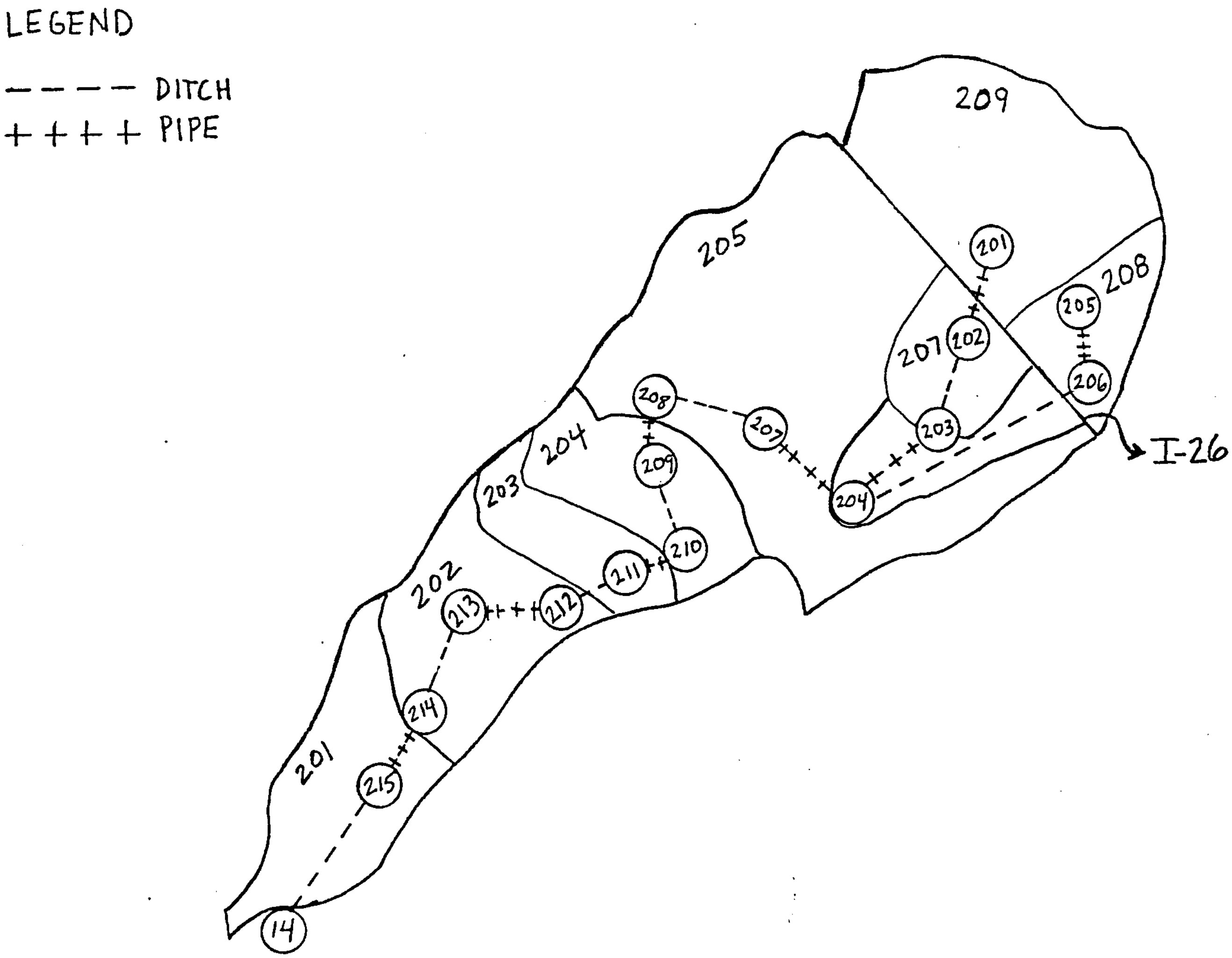


Figure 1. Link-Node Diagram



200 Series "Cut Out"

Figure 1a.

Lexington County, South Carolina

Design Storm		24 Hour Rainfall
2 Year		3.70
5 Year		4.75
10 year		5.45
25 Year		6.35
50 Year		7.10
100 Year		7.75

Figure 2

2 Year P = 3.70 inches

	Peak Runoff (cfs)				Percent Increase in Runoff				
Watershed Number	1970	1989	1995 Open Field	1995 Impervious Field	1970 to 1989	1989 to 1995 Open Field	1989 to 1995 Impervious Field	1970-1995 Open Field	1970-1995 Impervious Field
126	78.30	78.30	78.30	78.30	0.00	0.00	0.00	0.00	0.00
128	125.30	125.30	125.30	125.30	0.00	0.00	0.00	0.00	0.00
125	155.60	155.60	158.30	158.30	0.00	1.74	1.74	1.74	1.74
134	34.90	34.90	35.70	35.70	0.00	2.29	2.29	2.29	2.29
133	43.30	43.30	46.40	77.10	0.00	7.16	78.06	7.16	78.06
700	56.40	56.40	58.00	78.10	0.00	2.84	38.48	2.84	38.48
132	101.20	101.20	102.10	127.10	0.00	0.89	25.59	0.89	25.59
201	54.80	54.80	54.80	54.80	0.00	0.00	0.00	0.00	0.00
202	46.10	46.10	46.10	46.10	0.00	0.00	0.00	0.00	0.00
203	25.30	25.30	25.30	25.30	0.00	0.00	0.00	0.00	0.00
204	40.20	40.20	40.20	40.20	0.00	0.00	0.00	0.00	0.00
205	103.10	103.10	105.10	177.60	0.00	1.94	72.26	1.94	72.26
206	28.30	28.30	28.90	38.50	0.00	2.12	36.04	2.12	36.04
207	38.10	38.10	39.60	77.60	0.00	3.94	103.67	3.94	103.67
208	25.10	25.20	25.20	25.20	0.40	0.00	0.00	0.40	0.40
209	22.30	22.30	22.30	22.30	0.00	0.00	0.00	0.00	0.00

Nodes of Interest									
701	75.00	75.00	79.00	102.00	0.00	5.33	36.00	5.33	36.00
700	61.00	61.00	63.00	75.00	0.00	3.28	22.95	3.28	22.95
133	438.00	438.00	441.00	443.00	0.00	0.68	1.14	0.68	1.14
132	438.00	438.00	442.00	443.00	0.00	0.91	1.14	0.91	1.14
131	533.00	533.00	537.00	566.00	0.00	0.75	6.19	0.75	6.19
13	1313.00	1313.00	1316.00	1337.00	0.00	0.23	1.83	0.23	1.83
14	1430.00	1430.00	1433.00	1458.00	0.00	0.21	1.96	0.21	1.96

Table 1

5 Year P = 4.75 inches

Peak Runoff (cfs) | **Percent Increase in Runoff**

Watershed Number	1970	1989	1995 Open Field	1995 Impervious Field	1970 to 1989	1989 to 1995 Open Field	1989 to 1995 Impervious Field	1970-1995 Open Field	1970-1995 Impervious Field
126	119.70	119.70	119.70	119.70	0.00	0.00	0.00	0.00	0.00
128	194.40	194.40	194.40	194.40	0.00	0.00	0.00	0.00	0.00
125	219.00	219.00	222.00	222.00	0.00	1.37	1.37	1.37	1.37
134	61.80	61.80	62.90	62.90	0.00	1.78	1.78	1.78	1.78
133	68.90	68.90	73.00	112.50	0.00	5.95	63.28	5.95	63.28
700	85.20	85.20	87.10	109.60	0.00	2.23	28.64	2.23	28.64
132	152.40	152.40	153.50	185.80	0.00	0.72	21.92	0.72	21.92
201	79.00	79.00	79.00	79.00	0.00	0.00	0.00	0.00	0.00
202	67.80	67.80	67.80	67.80	0.00	0.00	0.00	0.00	0.00
203	37.60	37.60	37.60	37.60	0.00	0.00	0.00	0.00	0.00
204	60.20	60.20	60.20	60.20	0.00	0.00	0.00	0.00	0.00
205	158.70	158.70	161.10	252.80	0.00	1.51	59.29	1.51	59.29
206	41.40	41.40	42.00	51.90	0.00	1.45	25.36	1.45	25.36
207	57.10	57.10	58.90	100.10	0.00	3.15	75.31	3.15	75.31
208	37.90	37.90	37.90	37.90	0.00	0.00	0.00	0.00	0.00
209	41.90	41.90	41.90	41.90	0.00	0.00	0.00	0.00	0.00

Nodes of Interest									
701	128.00	128.00	133.00	163.00	0.00	3.91	27.34	3.91	27.34
700	105.00	105.00	123.00	153.00	0.00	17.14	45.71	17.14	45.71
133	630.00	630.00	632.00	634.00	0.00	0.32	0.63	0.32	0.63
132	630.00	630.00	632.00	634.00	0.00	0.32	0.63	0.32	0.63
131	776.00	776.00	779.00	815.00	0.00	0.39	5.03	0.39	5.03
13	1948.00	1948.00	1952.00	1984.00	0.00	0.21	1.85	0.21	1.85
14	2127.00	2127.00	2130.00	2164.00	0.00	0.14	1.74	0.14	1.74

Table 2

10 Year P = 5.45 inches

Watershed Number	Peak Runoff (cfs) 1970	1989	1995 Open Field	1995 Impervious Field	Percent Increase in Runoff 1970 to 1989	1989 to 1995 Open Field	1989 to 1995 Impervious Field	1970-1995 Open Field	1970-1995 Impervious Fiel
126	148.30	148.30	148.30	148.30	0.00	0.00	0.00	0.00	0.00
128	243.00	243.00	243.00	243.00	0.00	0.00	0.00	0.00	0.00
125	261.60	261.60	264.70	264.70	0.00	1.19	1.19	1.19	1.19
134	81.40	81.40	82.60	82.60	0.00	1.47	1.47	1.47	1.47
133	87.30	87.30	91.70	136.60	0.00	5.04	56.47	5.04	56.47
700	105.10	105.10	107.00	130.60	0.00	1.81	24.26	1.81	24.26
132	187.80	187.80	188.90	225.70	0.00	0.59	20.18	0.59	20.18
201	95.40	95.40	95.40	95.40	0.00	0.00	0.00	0.00	0.00
202	82.50	82.50	82.50	82.50	0.00	0.00	0.00	0.00	0.00
203	46.10	46.10	46.10	46.10	0.00	0.00	0.00	0.00	0.00
204	74.00	74.00	74.00	74.00	0.00	0.00	0.00	0.00	0.00
205	197.80	197.80	200.40	303.50	0.00	1.31	53.44	1.31	53.44
206	50.30	50.30	50.90	60.80	0.00	1.19	20.87	1.19	20.87
207	70.20	70.20	72.00	115.00	0.00	2.56	63.82	2.56	63.82
208	46.70	46.70	46.70	46.70	0.00	0.00	0.00	0.00	0.00
209	56.50	56.50	56.50	56.50	0.00	0.00	0.00	0.00	0.00

Nodes of Interest									
701	166.00	166.00	172.00	205.00	0.00	3.61	23.49	3.61	23.49
700	166.00	166.00	178.00	202.00	0.00	7.23	21.69	7.23	21.69
133	767.00	767.00	770.00	771.00	0.00	0.39	0.52	0.39	0.52
132	767.00	767.00	770.00	771.00	0.00	0.39	0.52	0.39	0.52
131	947.00	947.00	950.00	991.00	0.00	0.32	4.65	0.32	4.65
13	2355.00	2355.00	2359.00	2395.00	0.00	0.17	1.70	0.17	1.70
14	2575.00	2575.00	2579.00	2620.00	0.00	0.16	1.75	0.16	1.75

Table 3

25 Year P = 6.35 inches

	Peak Runoff (cfs)				Percent Increase in Runoff				
Watershed Number	1970	1989	1995 Open Field	1995 Impervious Field	1970 to 1989	1989 to 1995 Open Field	1989 to 1995 Impervious Field	1970-1995 Open Field	1970-1995 Impervious Fiel
126	185.90	185.90	185.90	185.90	0.00	0.00	0.00	0.00	0.00
128	307.10	307.10	307.10	307.10	0.00	0.00	0.00	0.00	0.00
125	316.40	316.40	319.60	319.60	0.00	1.01	1.01	1.01	1.01
134	107.90	107.90	109.30	109.30	0.00	1.30	1.30	1.30	1.30
133	111.60	111.60	116.50	167.80	0.00	4.39	50.36	4.39	50.36
700	131.00	131.00	133.10	157.60	0.00	1.60	20.31	1.60	20.31
132	234.10	234.10	235.30	277.60	0.00	0.51	18.58	0.51	18.58
201	116.50	116.50	116.50	116.50	0.00	0.00	0.00	0.00	0.00
202	101.60	101.60	101.60	101.60	0.00	0.00	0.00	0.00	0.00
203	57.10	57.10	57.10	57.10	0.00	0.00	0.00	0.00	0.00
204	92.00	92.00	92.00	92.00	0.00	0.00	0.00	0.00	0.00
205	249.40	249.40	252.20	368.90	0.00	1.12	47.91	1.12	47.91
206	61.80	61.80	62.40	72.10	0.00	0.97	16.67	0.97	16.67
207	87.30	87.30	89.20	134.30	0.00	2.18	53.84	2.18	53.84
208	58.10	58.10	58.10	58.10	0.00	0.00	0.00	0.00	0.00
209	76.60	76.60	76.60	76.60	0.00	0.00	0.00	0.00	0.00

Nodes of Interest									
701	217.00	217.00	223.00	262.00	0.00	2.76	20.74	2.76	20.74
700	230.00	230.00	238.00	260.00	0.00	3.48	13.04	3.48	13.04
133	946.00	946.00	949.00	950.00	0.00	0.32	0.42	0.32	0.42
132	946.00	946.00	949.00	950.00	0.00	0.32	0.42	0.32	0.42
131	1171.00	1171.00	1176.00	1224.00	0.00	0.43	4.53	0.43	4.53
13	2873.00	2873.00	2877.00	2921.00	0.00	0.14	1.67	0.14	1.67
14	3159.00	3159.00	3163.00	3209.00	0.00	0.13	1.58	0.13	1.58

Table 4

50 Year P = 7.10 inches

Watershed Number	1970	1989	1995 Open Field	1995 Impervious Field	1970 to 1989	1989 to 1995 Open Field	1989 to 1995 Impervious Field	1970-1995 Open Field	1970-1995 Impervious Field
	Peak Runoff (cfs)				Percent Increase in Runoff				
126	217.60	217.60	217.60	217.60	0.00	0.00	0.00	0.00	0.00
128	361.40	361.40	361.40	361.40	0.00	0.00	0.00	0.00	0.00
125	362.00	362.00	365.30	365.30	0.00	0.91	0.91	0.91	0.91
134	131.10	131.10	132.70	132.70	0.00	1.22	1.22	1.22	1.22
133	132.20	132.20	137.50	193.80	0.00	4.01	46.60	4.01	46.60
700	152.80	152.80	155.00	180.10	0.00	1.44	17.87	1.44	17.87
132	273.10	273.10	274.40	321.00	0.00	0.48	17.54	0.48	17.54
201	134.10	134.10	134.10	134.10	0.00	0.00	0.00	0.00	0.00
202	117.60	117.60	117.60	117.60	0.00	0.00	0.00	0.00	0.00
203	66.30	66.30	66.30	66.30	0.00	0.00	0.00	0.00	0.00
204	107.10	107.10	107.10	107.10	0.00	0.00	0.00	0.00	0.00
205	293.00	293.00	295.90	423.30	0.00	0.99	44.47	0.99	44.47
206	71.40	71.40	72.00	81.60	0.00	0.84	14.29	0.84	14.29
207	101.60	101.60	103.50	150.30	0.00	1.87	47.93	1.87	47.93
208	67.70	67.70	67.70	67.70	0.00	0.00	0.00	0.00	0.00
209	94.50	94.50	94.50	94.50	0.00	0.00	0.00	0.00	0.00

Nodes of Interest									
701	261.00	261.00	268.00	310.00	0.00	2.68	18.77	2.68	18.77
700	272.00	272.00	268.00	319.00	0.00	-1.47	17.28	-1.47	17.28
133	1093.00	1093.00	1096.00	1097.00	0.00	0.27	0.37	0.27	0.37
132	1093.00	1093.00	1096.00	1097.00	0.00	0.27	0.37	0.27	0.37
131	1354.00	1354.00	1359.00	1411.00	0.00	0.37	4.21	0.37	4.21
13	3280.00	3280.00	3284.00	3333.00	0.00	0.12	1.62	0.12	1.62
14	3616.00	3616.00	3620.00	3674.00	0.00	0.11	1.60	0.11	1.60

Table 5

100 Year   P = 7.75 inches

Watershed Number	Peak Runoff (cfs) 1970	1989	1995 Open Field	1995 Impervious Field	Percent Increase in Runoff 1970 to 1989	1989 to 1995 Open Field	1989 to 1995 Impervious Field	1970-1995 Open Field	1970-1995 Impervious Field
126	245.20	245.20	245.20	245.20	0.00	0.00	0.00	0.00	0.00
128	408.90	408.90	408.90	408.90	0.00	0.00	0.00	0.00	0.00
125	401.50	401.50	404.70	404.70	0.00	0.80	0.80	0.80	0.80
134	151.90	151.90	153.60	153.60	0.00	1.12	1.12	1.12	1.12
133	150.40	150.40	155.90	216.50	0.00	3.66	43.95	3.66	43.95
700	171.80	171.80	174.00	199.50	0.00	1.28	16.12	1.28	16.12
132	307.20	307.20	308.40	358.80	0.00	0.39	16.80	0.39	16.80
201	149.40	149.40	149.40	149.40	0.00	0.00	0.00	0.00	0.00
202	131.50	131.50	131.50	131.50	0.00	0.00	0.00	0.00	0.00
203	74.30	74.30	74.30	74.30	0.00	0.00	0.00	0.00	0.00
204	120.20	120.20	120.20	120.20	0.00	0.00	0.00	0.00	0.00
205	331.10	331.10	334.00	470.40	0.00	0.88	42.07	0.88	42.07
206	79.70	79.70	80.30	89.70	0.00	0.75	12.55	0.75	12.55
207	114.10	114.10	116.00	164.10	0.00	1.67	43.82	1.67	43.82
208	76.10	76.10	76.10	76.10	0.00	0.00	0.00	0.00	0.00
209	110.40	110.40	110.40	110.40	0.00	0.00	0.00	0.00	0.00

Nodes of Interest									
701	300.00	300.00	307.00	352.00	0.00	2.33	17.33	2.33	17.33
700	314.00	314.00	306.00	346.00	0.00	-2.55	10.19	-2.55	10.19
133	1219.00	1219.00	1223.00	1223.00	0.00	0.33	0.33	0.33	0.33
132	1219.00	1219.00	1223.00	1223.00	0.00	0.33	0.33	0.33	0.33
131	1509.00	1509.00	1513.00	1570.00	0.00	0.27	4.04	0.27	4.04
13	3642.00	3642.00	3645.00	3698.00	0.00	0.08	1.54	0.08	1.54
14	4019.00	4019.00	4023.00	4077.00	0.00	0.10	1.44	0.10	1.44

Table 6

percent increases in runoff as great as 45 percent. If we ignore nodes 700 and 701, we still experience increases as great as 6 percent in downstream nodes. Although 6 percent is significantly greater than the 1 percent observed in the previous analysis, it is often treated by regulations as an overall insignificant change to the impacted watershed.

Once we observed the relatively insignificant effects in the downstream nodes, we turned our attention to Grove Park Pond. When running the Drain:Edge program for all four models, Grove Park Pond over-topped at the 5 year and less frequent storm events. We examined the pond stage-storage and stage discharge relationships. Figure 3 shows these relationships. When we observed the stage-discharge data, we concluded that the outlet device was weir controlled for the first four feet and orifice controlled for the remaining four feet. Table 7 illustrates the governing stage-discharge equations for the Grove Park Pond outlet device. These relationships were developed by performing a linear regression analysis on the available data. At this point, we consulted Lexington County for feasible pond enlargement information. Lexington County provided Figure 4, a contour map of the land adjacent to the Grove Park Pond detention site. From discussions with Lexington County, we learned that the Grove Park Pond is scheduled to be enlarged in the near future to a 2-3 acre detention site. The depth of the pond is to remain at eight feet. With this information, we modelled the proposed changes to Grove Park Pond with an **inverted quadrilateral frustum**. Table 8 shows the stage-

Grove Park Pond Outlet Device
(original)

Elevation (FT)	Stage (FT)	Outflow (cfs)	Storage (FT^3)
222.0	0.0	0.0	0.0
223.0	1.0	6.5	4571.0
224.0	2.0	18.0	14634.0
225.0	3.0	32.8	26671.0
226.0	4.0	47.7	40379.0
227.0	5.0	59.0	55451.0
228.0	6.0	68.8	71763.0
229.0	7.0	77.3	89607.0
230.0	8.0	85.0	110530.0

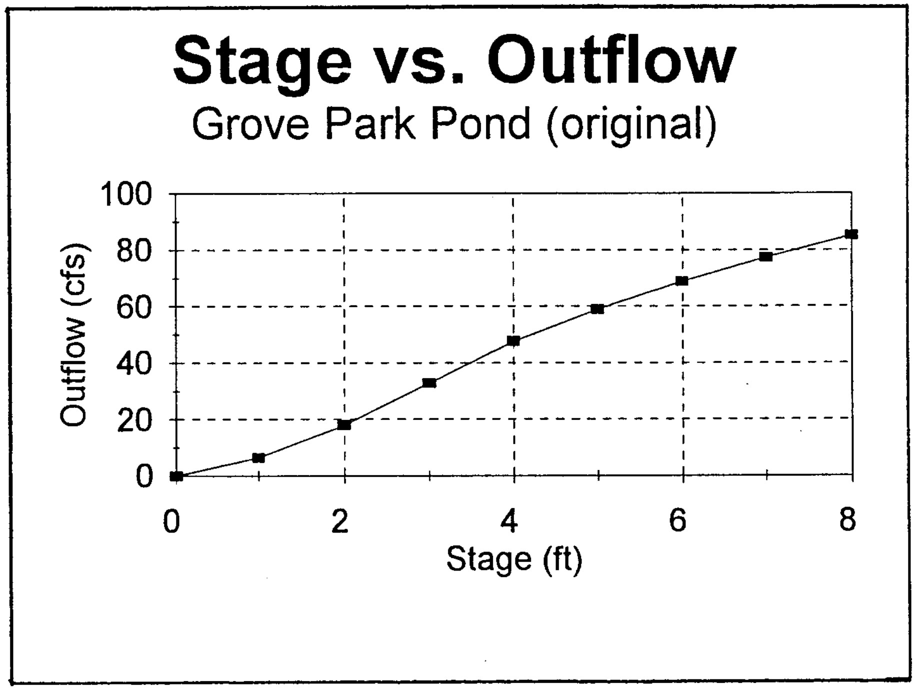


Figure 3

Grove Park Pond

(original)

Wier Control 0.0 < H < 4.0 Y = 6.55 * H^1.45

Qo = 0

Height (ft)	log H	Q (cfs)	Log (Q-Qo)	log H * log (Q-Qo)	(log H)^2	ABS error	Qapprox (cfs)
1.00	0.000	6.50	0.813	0.000	0.000	0.004	6.55
2.00	0.301	18.00	1.255	0.378	0.091	0.003	17.86
3.00	0.477	32.80	1.516	0.723	0.228	0.009	32.11
4.00	0.602	47.70	1.679	1.011	0.362	0.009	48.69
Sum:	1.380		5.263	2.112	0.681	0.025	

Data Pts	n =	4		
Slope	a =	1.45		
Intercept	b =	0.82	k =	6.55

Oriface Control 5.0 < H < 8.0 Y = 16.99 * H^0.78

Qo = 0

Height (ft)	log H	Q (cfs)	Log (Q-Qo)	log H * log (Q-Qo)	(log H)^2	ABS error	Qapprox (cfs)
5	0.699	59	1.771	1.238	0.489	0.002	59.31
6.00	0.778	68.80	1.838	1.430	0.606	0.003	68.33
7.00	0.845	77.30	1.888	1.596	0.714	0.002	77.02
8.00	0.903	85.00	1.929	1.742	0.816	0.002	85.44
Sum:	3.225		7.426	6.006	2.624	0.009	

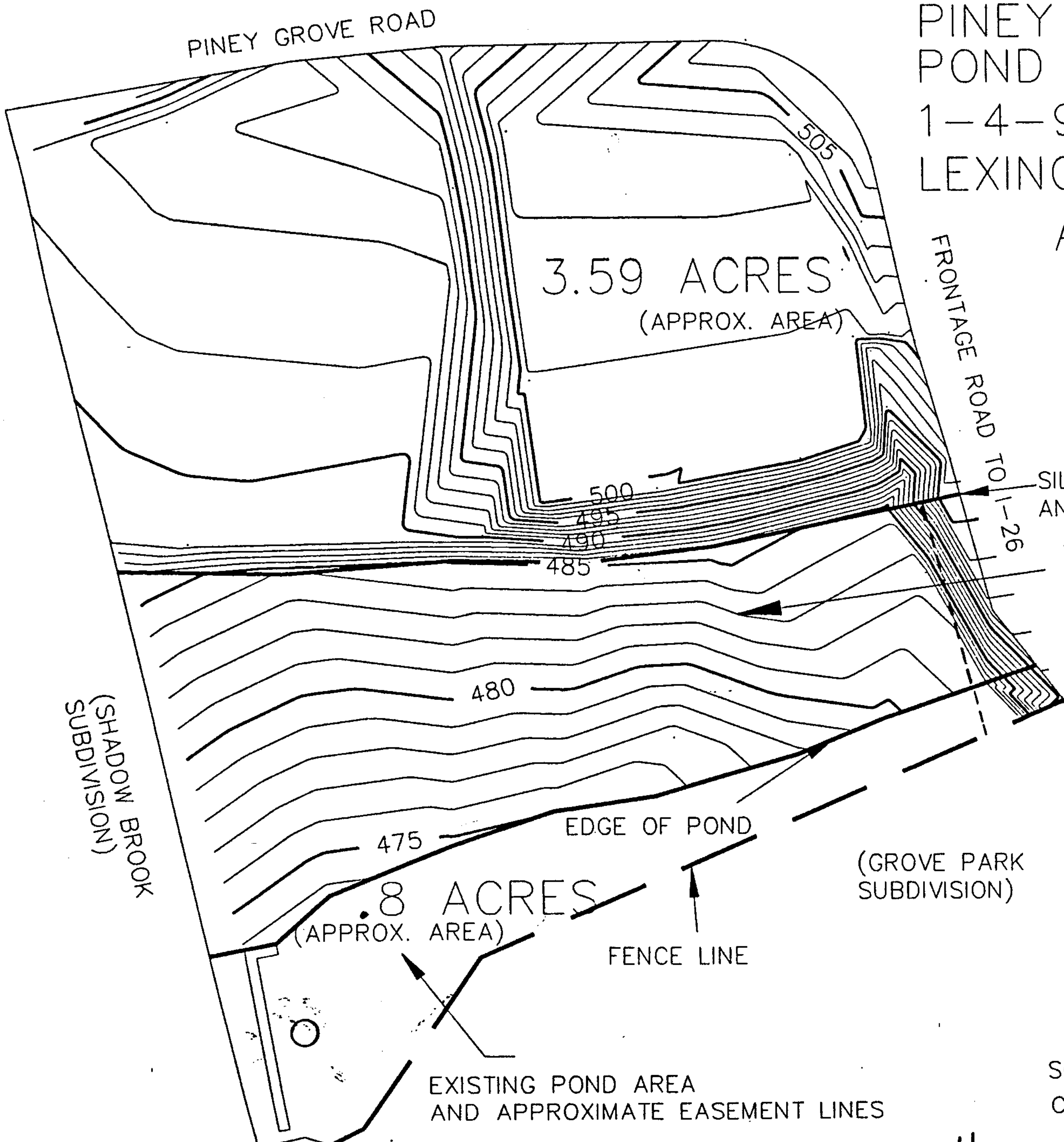
Data Pts	n =	4		
Slope	a =	0.78		
Intercept	b =	1.23	k =	16.99

Table 7

PINEY GROVE DETENTION POND SITE

1-4-95

LEXINGTON COUNTY PLANNING AND DEVELOPMENT



TMS 02898-020004

SCALE: 1" = 100'
CONTOUR INTERVAL = 1'

Figure 4

storage relationship determined from the proposed pond dimensions. We altered the batch files to reflect the new stage-storage relationship for the Grove Park Pond keeping the outlet device unchanged and again ran the 1995 models for the 2, 5, 10 and 25 year storm events. Tables 9 through 12 illustrate significant decreases in runoff at downstream nodes as a result of the Grove Park Pond expansion. Specifically, at node 701 (the outfall of Grove Park Pond) we experienced decreases in runoff ranging from 69 to 75 percent throughout the different storm events. Closer observation shows that the enlarged ponds ability to decrease runoff rates lessens with increasing storm event return period. In other words, the enlarged pond is most effective in reducing runoff in the downstream nodes for the 2 year storm event. Table 9 illustrates that some downstream nodes decreased by as much as 11 percent where as the most remote downstream node decreased by 3 percent. These values reflect the comparison of the 1989 condition to the 1995 open field condition. We notice similar reductions when the 1995 impervious field condition is compared, however, the magnitude of reduction consistently lags the 1995 open field values (see Tables 9 through 12).

Lastly, we considered replacing the outlet device on Grove Park Pond with a V-notch weir. This change was implemented because of Lexington County's desire to drastically detain frequent storm events while allowing less frequent events to pass through more quickly. They reasoned that a V-notch outlet device would lessen the flooding downstream of the pond for the frequent storm events.

Grove Park Pond Stage-Storage Calculations

Base Length =	500	feet
Base Width =	235	feet
Z =	3	
Delta Storage =	1	feet

Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Average Area (ft^2)	Delta Storage (ft^3)	Storage (ft^3)
0	500	235	117500			0
				119723	119723	
1	506	241	121946			119723
				124205	124205	
2	512	247	126464			243928
				128759	128759	
3	518	253	131054			372687
				133385	133385	
4	524	259	135716			506072
				138083	138083	
5	530	265	140450			644155
				142853	142853	
6	536	271	145256			787008
				147695	147695	
7	542	277	150134			934703
				152609	152609	
8	548	283	155084			1087312

Table 8

Grove Park Pond Enlargement

2 Year P = 3.70 inches

	Peak Runoff (cfs)				Percent Increase in Runoff	
Watershed Number	1995 Open Field	1995 Open Field (Enlarged Pond)	1995 Impervious Field	1995 Impervious Field (Enlarged Pond)	1995 Open Field (Pond Improvements)	1989 to 1995 Impervious Field (Pond Improvements)
126	78.30	78.30	78.30	78.30	0.00	0.00
128	125.30	125.30	125.30	125.30	0.00	0.00
125	158.30	158.30	158.30	158.30	0.00	0.00
134	35.70	35.70	35.70	35.70	0.00	0.00
133	46.40	46.40	77.10	77.10	0.00	0.00
700	58.00	58.00	78.10	78.10	0.00	0.00
132	102.10	102.10	127.10	127.10	0.00	0.00
201	54.80	54.80	54.80	54.80	0.00	0.00
202	46.10	46.10	46.10	46.10	0.00	0.00
203	25.30	25.30	25.30	25.30	0.00	0.00
204	40.20	40.20	40.20	40.20	0.00	0.00
205	105.10	105.10	177.60	177.60	0.00	0.00
206	28.90	28.90	38.50	38.50	0.00	0.00
207	39.60	39.60	77.60	77.60	0.00	0.00
208	25.20	25.20	25.20	25.20	0.00	0.00
209	22.30	22.30	22.30	22.30	0.00	0.00

Nodes of Interest						
701	79.00	79.00	102.00	102.00	0.00	0.00
700	63.00	18.00	75.00	23.00	-71.43	-69.33
133	441.00	391.00	443.00	399.00	-11.34	-9.93
132	442.00	391.00	443.00	399.00	-11.54	-9.93
131	537.00	489.00	566.00	523.00	-8.94	-7.60
13	1316.00	1271.00	1337.00	1299.00	-3.42	-2.84
14	1433.00	1387.00	1458.00	1417.00	-3.21	-2.81

Table 9

Grove Park Pond Enlargement

5 Year P = 4.75 inches

	Peak Runoff (cfs)				Percent Increase in Runoff	
Watershed Number	1995 Open Field	1995 Open Field (Enlarged Pond)	1995 Impervious Field	1995 Impervious Field (Enlarged Pond)	1995 Open Field (Pond Improvements)	1989 to 1995 Impervious Field (Pond Improvements)
126	119.70	119.70	119.70	119.70	0.00	0.00
128	194.40	194.40	194.40	194.40	0.00	0.00
125	222.00	222.00	222.00	222.00	0.00	0.00
134	62.90	62.90	62.90	62.90	0.00	0.00
133	73.00	73.00	112.50	112.50	0.00	0.00
700	87.10	87.10	109.60	109.60	0.00	0.00
132	153.50	153.50	185.80	185.80	0.00	0.00
201	79.00	79.00	79.00	79.00	0.00	0.00
202	67.80	67.80	67.80	67.80	0.00	0.00
203	37.60	37.60	37.60	37.60	0.00	0.00
204	60.20	60.20	60.20	60.20	0.00	0.00
205	161.10	161.10	252.80	252.80	0.00	0.00
206	42.00	42.00	51.90	51.90	0.00	0.00
207	58.90	58.90	100.10	100.10	0.00	0.00
208	37.90	37.90	37.90	37.90	0.00	0.00
209	41.90	41.90	41.90	41.90	0.00	0.00

Nodes of Interest						
701	133.00	133.00	163.00	163.00	0.00	0.00
700	123.00	34.00	153.00	40.00	-72.36	-73.86
133	632.00	591.00	634.00	603.00	-6.49	-4.89
132	632.00	591.00	634.00	603.00	-6.49	-4.89
131	779.00	740.00	815.00	785.00	-5.01	-3.68
13	1952.00	1916.00	1984.00	1958.00	-1.84	-1.31
14	2130.00	2092.00	2164.00	2136.00	-1.78	-1.29

Table 10

Grove Park Pond Enlargement

10 Year P = 5.45 inches

	Peak Runoff (cfs)				Percent Increase in Runoff	
Watershed Number	1995 Open Field	1995 Open Field (Enlarged Pond)	1995 Impervious Field	1995 Impervious Field (Enlarged Pond)	1995 Open Field (Pond Improvements)	1989 to 1995 Impervious Field (Pond Improvements)
126	148.30	148.30	148.30	148.30	0.00	0.00
128	243.00	243.00	243.00	243.00	0.00	0.00
125	264.70	264.70	264.70	264.70	0.00	0.00
134	82.60	82.60	82.60	82.60	0.00	0.00
133	91.70	91.70	136.60	136.60	0.00	0.00
700	107.00	107.00	130.60	130.60	0.00	0.00
132	188.90	188.90	225.70	225.70	0.00	0.00
201	95.40	95.40	95.40	95.40	0.00	0.00
202	82.50	82.50	82.50	82.50	0.00	0.00
203	46.10	46.10	46.10	46.10	0.00	0.00
204	74.00	74.00	74.00	74.00	0.00	0.00
205	200.40	200.40	303.50	303.50	0.00	0.00
206	50.90	50.90	60.80	60.80	0.00	0.00
207	72.00	72.00	115.00	115.00	0.00	0.00
208	46.70	46.70	46.70	46.70	0.00	0.00
209	56.50	56.50	56.50	56.50	0.00	0.00

Nodes of Interest						
701	172.00	172.00	205.00	205.00	0.00	0.00
700	178.00	45.00	202.00	51.00	-74.72	-74.75
133	770.00	738.00	771.00	750.00	-4.16	-2.72
132	770.00	738.00	771.00	750.00	-4.16	-2.72
131	950.00	921.00	991.00	972.00	-3.05	-1.92
13	2359.00	2333.00	2395.00	2380.00	-1.10	-0.63
14	2579.00	2551.00	2620.00	2599.00	-1.09	-0.80

Table 11

Grove Park Pond Enlargement

25 Year P = 6.35 inches

	Peak Runoff (cfs)				Percent Increase in Runoff	
Watershed Number	1995 Open Field	1995 Open Field (Enlarged Pond)	1995 Impervious Field	1995 Impervious Field (Enlarged Pond)	1995 Open Field (Pond Improvements)	1989 to 1995 Impervious Field (Pond Improvements)
126	185.90	185.90	185.90	185.90	0.00	0.00
128	307.10	307.10	307.10	307.10	0.00	0.00
125	319.60	319.60	319.60	319.60	0.00	0.00
134	109.30	109.30	109.30	109.30	0.00	0.00
133	116.50	116.50	167.80	167.80	0.00	0.00
700	133.10	133.10	157.60	157.60	0.00	0.00
132	235.30	235.30	277.60	277.60	0.00	0.00
201	116.50	116.50	116.50	116.50	0.00	0.00
202	101.60	101.60	101.60	101.60	0.00	0.00
203	57.10	57.10	57.10	57.10	0.00	0.00
204	92.00	92.00	92.00	92.00	0.00	0.00
205	252.20	252.20	368.90	368.90	0.00	0.00
206	62.40	62.40	72.10	72.10	0.00	0.00
207	89.20	89.20	134.30	134.30	0.00	0.00
208	58.10	58.10	58.10	58.10	0.00	0.00
209	76.60	76.60	76.60	76.60	0.00	0.00

Nodes of Interest						
701	223.00	223.00	262.00	262.00	0.00	0.00
700	238.00	58.00	260.00	63.00	-75.63	-75.77
133	949.00	929.00	950.00	942.00	-2.11	-0.84
132	949.00	929.00	950.00	942.00	-2.11	-0.84
131	1176.00	1157.00	1224.00	1215.00	-1.62	-0.74
13	2877.00	2863.00	2921.00	2917.00	-0.49	-0.14
14	3163.00	3146.00	3209.00	3203.00	-0.54	-0.19

Table 12

To verify their reasoning, we designed three V-notch weirs with 30, 45, and 60 degree notches, respectfully. Figure 5 illustrates the stage-discharge relationship for the weirs as well as their rating curve profile. With this information we altered the batch files and again ran the Drain:Edge program for the 2 and 25 year storm events. Tables 13 and 14 summarize the results. As we anticipated, the percent decrease in runoff experienced at the downstream nodes was directly related to the size of the notch. The greatest reductions were accomplished by the 30 degree V-notch weir for both the 2 and 25 year storm events. However, caution must be exercised if a V-notch weir is to replace the existing outlet device. When comparing Table 9 to Table 13 and Table 12 to Table 14, we see inconsistent results in peak reductions in the downstream nodes. For instance, the immediate downstream nodes may experience a greater runoff reduction with the V-notch weir, but more remote nodes actually experience a lesser reduction and in some cases even an increase in runoff vice a reduction at all. Because of this phenomenon, outlet device changes should be scrutinized carefully.

V-Notch Weir

Stage (ft)	Outflow (cfs) 30 degrees	45 degrees	60 degrees
0	0	0	0
1	0.66	1.03	1.43
2	3.76	5.81	8.1
3	10.36	16.01	22.32
4	21.26	32.87	45.82
5	37.15	57.43	80.04
6	58.6	90.58	126.26
7	86.15	133.17	185.62
8	120.29	185.95	259.19

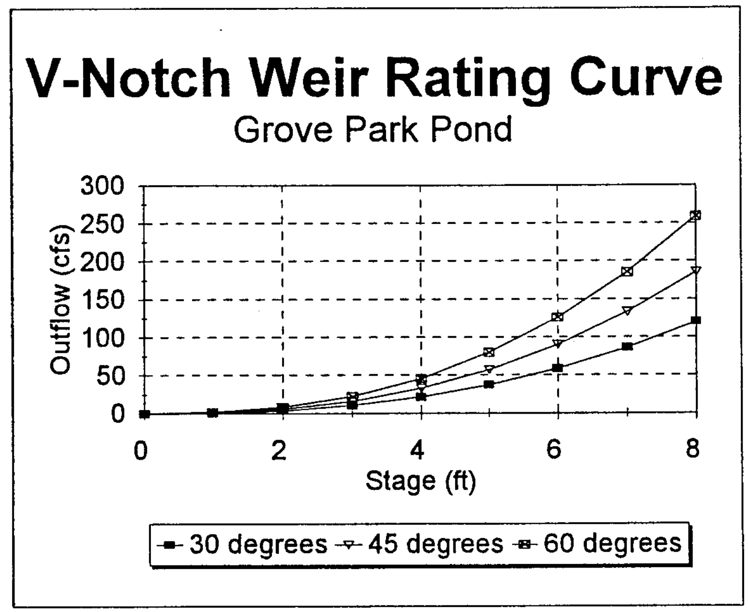


Figure 5

Proposed Enhancements to Grove Park Pond

2 Year P = 3.70 inches

Peak Runoff (cfs) at nodes of interest

nodes of interest	1989 Pre-existing conditions	1995 Open Fields Enlarged Pond Unchanged Outlet Device	1995 Impervious Fields Enlarged Pond Unchanged Outlet Device	1995 Impervious Fields Enlarged Pond V-Notch Weir, 30 degrees	1995 Impervious Fields Enlarged Pond V-Notch Weir, 45 degrees	1995 Impervious Fields Enlarged Pond V-Notch Weir, 60 degrees
700.00	75.00	79.00	102.00	102.00	102.00	102.00
701.00	61.00	63.00	75.00	10.00	14.00	17.00
133.00	438.00	441.00	443.00	388.00	389.00	391.00
132.00	438.00	442.00	443.00	388.00	389.00	391.00
131.00	533.00	537.00	566.00	512.00	513.00	515.00
13.00	1313.00	1316.00	1337.00	1286.00	1288.00	1291.00
14.00	1430.00	1433.00	1458.00	1404.00	1407.00	1409.00

Pre-existing Conditions (1989) vs. Proposed Enhancements

2 Year P = 3.70 inches

Percent Runoff (cfs) at nodes of interest

nodes of interest	1989 vs 1995 Open Field	1989 vs 1995 Imp Field Unchanged Outlet Device	1989 vs 1995 Imp Field V-Notch Weir, 30 degrees	1989 vs 1995 Imp Field V-Notch Weir, 45 degrees	1989 vs 1995 Imp Field V-Notch Weir, 60 degrees
700.00	5.33	36.00	36.00	36.00	36.00
701.00	3.28	22.95	-83.61	-77.05	-72.13
133.00	0.68	1.14	-11.42	-11.19	-10.73
132.00	0.91	1.14	-11.42	-11.19	-10.73
131.00	0.75	6.19	-3.94	-3.75	-3.38
13.00	0.23	1.83	-2.06	-1.90	-1.68
14.00	0.21	1.96	-1.82	-1.61	-1.47

(+) indicates pre-existing conditions exceeded
(-) indicates pre-existing conditions not exceeded

Table 13

Proposed Enhancements to Grove Park Pond

25 Year P = 6.35 inches

Peak Runoff (cfs) at nodes of interest

nodes of interest	1989 Pre-existing conditions	1995 Open Fields Enlarged Pond Unchanged Outlet Device	1995 Impervious Fields Enlarged Pond Unchanged Outlet Device	1995 Impervious Fields Enlarged Pond V-Notch Weir, 30 degrees	1995 Impervious Fields Enlarged Pond V-Notch Weir, 45 degrees	1995 Impervious Fields Enlarged Pond V-Notch Weir, 60 degrees
700.00	217.00	223.00	262.00	262.00	262.00	262.00
701.00	230.00	58.00	63.00	58.00	76.00	91.00
133.00	946.00	929.00	942.00	923.00	937.00	950.00
132.00	946.00	929.00	942.00	923.00	937.00	950.00
131.00	1171.00	1157.00	1215.00	1195.00	1211.00	1221.00
13.00	2873.00	2863.00	2917.00	2900.00	2916.00	2921.00
14.00	3159.00	3146.00	3203.00	3185.00	3200.00	3208.00

Pre-existing Conditions (1989) vs. Proposed Enhancements

25 Year P = 6.35 inches

Percent Runoff (cfs) at nodes of interest

nodes of interest	1989 vs 1995 Open Field	1989 vs 1995 Imp Field Unchanged Outlet Device	1989 vs 1995 Imp Field V-Notch Weir, 30 degrees	1989 vs 1995 Imp Field V-Notch Weir, 45 degrees	1989 vs 1995 Imp Field V-Notch Weir, 60 degrees
700.00	2.76	20.74	20.74	20.74	20.74
701.00	-74.78	-72.61	-74.78	-66.96	-60.43
133.00	-1.80	-0.42	-2.43	-0.95	0.42
132.00	-1.80	-0.42	-2.43	-0.95	0.42
131.00	-1.20	3.76	2.05	3.42	4.27
13.00	-0.35	1.53	0.94	1.50	1.67
14.00	-0.41	1.39	0.82	1.30	1.55

(+) indicates pre-existing conditions exceeded
(-) indicates pre-existing conditions not exceeded

Table 14

CONCLUSIONS

1. The GIS system currently being used by the Lexington County Department of Planning and Development has extensive capabilities in watershed modeling for planning purposes. We have only scratched the surface of its capabilities during the course of this project; however, we now realize the benefit of using such a system in conjunction with other models such as the Drain:Edge Program.

2. Because we had trouble defining a "before" construction condition, we conducted our analysis of incremental effects of road construction on the Kinley Creek Watershed by holding everything else constant and changing isolated pieces of the pie. Although this approach may leave the bottom line numbers we generated quasi-defendable in court, we believe they do give us an indication of the relative impacts of the various changes.

3. Having witnessed an actual 5-year storm event during this project, there is no doubt that there is a flooding problem in the respective areas discussed in this report. Of primary concern is the condition of the clay borrow-pit Northeast of the Grove Park Subdivision. Although considerable (and successful) efforts have been made to stabilize the side slopes around the borrow-pit, only minimal vegetative cover

has been established within the confines of the borrow-pit. Bottom line: the borrow-pit is approaching an impervious surface condition with excessive clay-carrying runoff leaving the site. The only solution to the clay problem is to prevent the clay from leaving the site. For whatever reason, DHEC seems satisfied with the borrow pit stabilization efforts undertaken by the contractor (under contract by DOT) to date. Frankly, this is surprising considering the extent and composition of the runoff and the documented headaches it is causing!

4. Because many of the homes in the Grove Park Subdivision and on Lewisham Road are constructed in the flood plain, they are always subject to flooding during high intensity storms.

5. The Grove Park Pond is inadequate by any measure. Both the DOT and Lexington County Planning and Development recognize this and have initiated appropriate action to modify/enlarge the pond.

6. Although it was beyond the scope of this project, it is apparent that many of the road crossings in the Kinley Creek Watershed are inadequate even during high frequency storms.

RECOMMENDATIONS

1. Lexington County Planning and Development should continue to expand its use of the GIS system as they are currently doing.

2. In order to more precisely define the watershed characteristics, the GIS data base (primarily, the road sizes and land uses) needs to be updated periodically.

3. The clay borrow-pit needs to be further stabilized to minimize clay runoff from the pit itself. Apparently, the area has been hydro-seeded in the past; however, frequent thunderstorms this spring and summer have washed most of the seed to the bottom 25% of the pit, leaving the remaining 75% with no vegetative cover.

4. Lexington County should design and modify (enlarge) the existing Grove Park Pond as currently planned.

5. A long range plan should be developed to upgrade/replace undersized road crossings in the Kinley Creek Watershed.